The impacts of East Siberian blocking on the development of the JPCZ

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*Akira Yamazaki[1], Shin Fukui[2], Shiori Sugimoto[1] (1: JAMSTEC, 2: Meteorological Research Institute)

Abstract

- Dynamical downscaling experiments were performed to investigate the influence of East Siberian blocking on a heavy snowfall event that occurred over Fukui City, Japan, in early February 2018 and was associated with the development of the JPCZ.
- The downscaling experiments simulated the JPCZ, and the enhancement of the East Asian cold air stream and its flow along two routes: the western route, which runs from the Eurasian Continent via the Yellow Sea and the Korean Peninsula; and the northern route, which originates in the Sea of Okhotsk and runs via the northern Japan Sea.
- For the sensitivity experiments, the blocking that develops over East Siberia just prior to the formation of the JPCZ was removed, and the results indicate that the East Siberian blocking contributes significantly to JPCZ development by enhancing the East Asian cold air stream along the western route.
- Data analyses based on the 20-year reanalysis revealed that East Siberian blocking can enhance both the western and northern routes of the cold air streams.

1. Simulation accuracy of the JPCZ event in February 2018

- **RRJ-Conv**: NHM-LETKF reanalysis system (Fukui et al. 2018), 25-km & 5-km domains, JRA-55 lateral boundary.
- **DS_{CTL}**: Dynamical downscaling experiment initialized at 1 February 2018 using RRJ-Conv. **$DS_{no\text{-}block}$**: Same as DS_{CTL} but the East Siberian blocking (Fig. 2) is removed from the lateral boundary based on I_{ESB} ($0 \leqq I_{ESB} \leqq 1$).

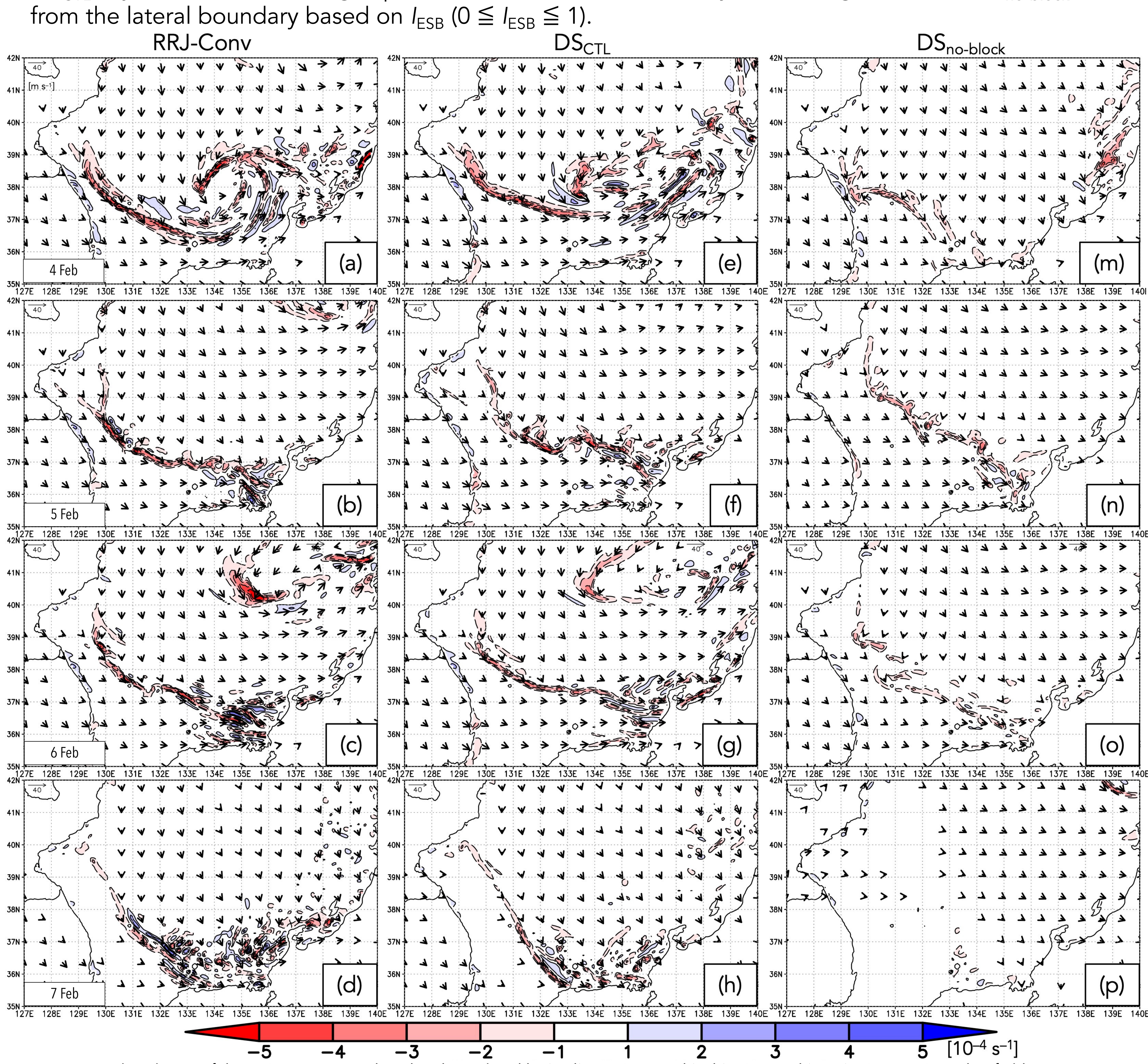

Fig. 1: Temporal evolution of the JPCZ event reproduced and simulated by (a–d) RRJ-Conv and (e–h) DS_{CTL}, and (m–p) $DS_{no\text{-}block}$. Snapshot fields at 00UTC on 4–7 February 2018 of 925-hPa divergence [10^{-4} s^{-1}] (shading) and wind [m s^{-1}] (arrows) are shown.

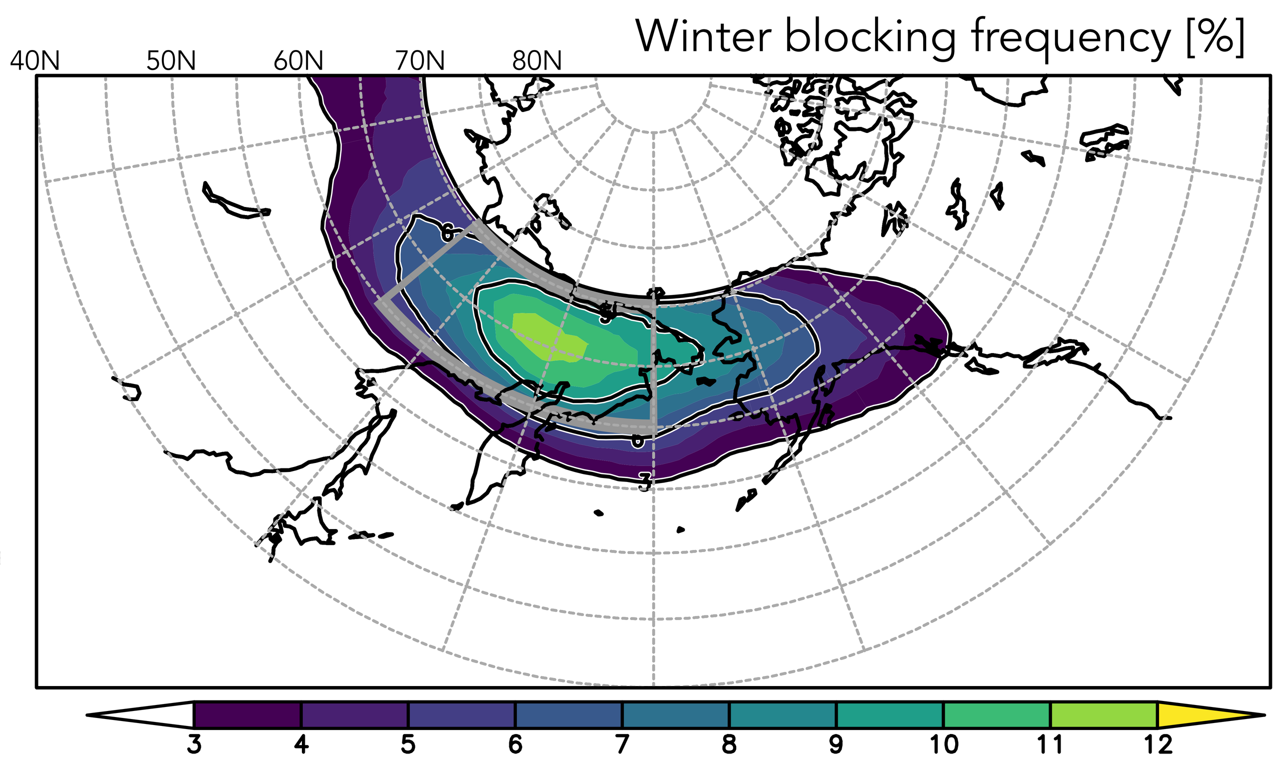

Fig. 2: Frequency distribution of climatological blocking [%] over the period December–February during 1979/80–2017/18, using data from JRA-55. The blocking index is based on Woollings et al.'s (2018) absolute method algorithm. The gray square indicates the East Siberian region to calculate a time series of an East Siberian blocking index (I_{ESB}).

2. Routes of the western and northern cold airmasses

Cold airmass flux by Iwasaki et al. (2014)

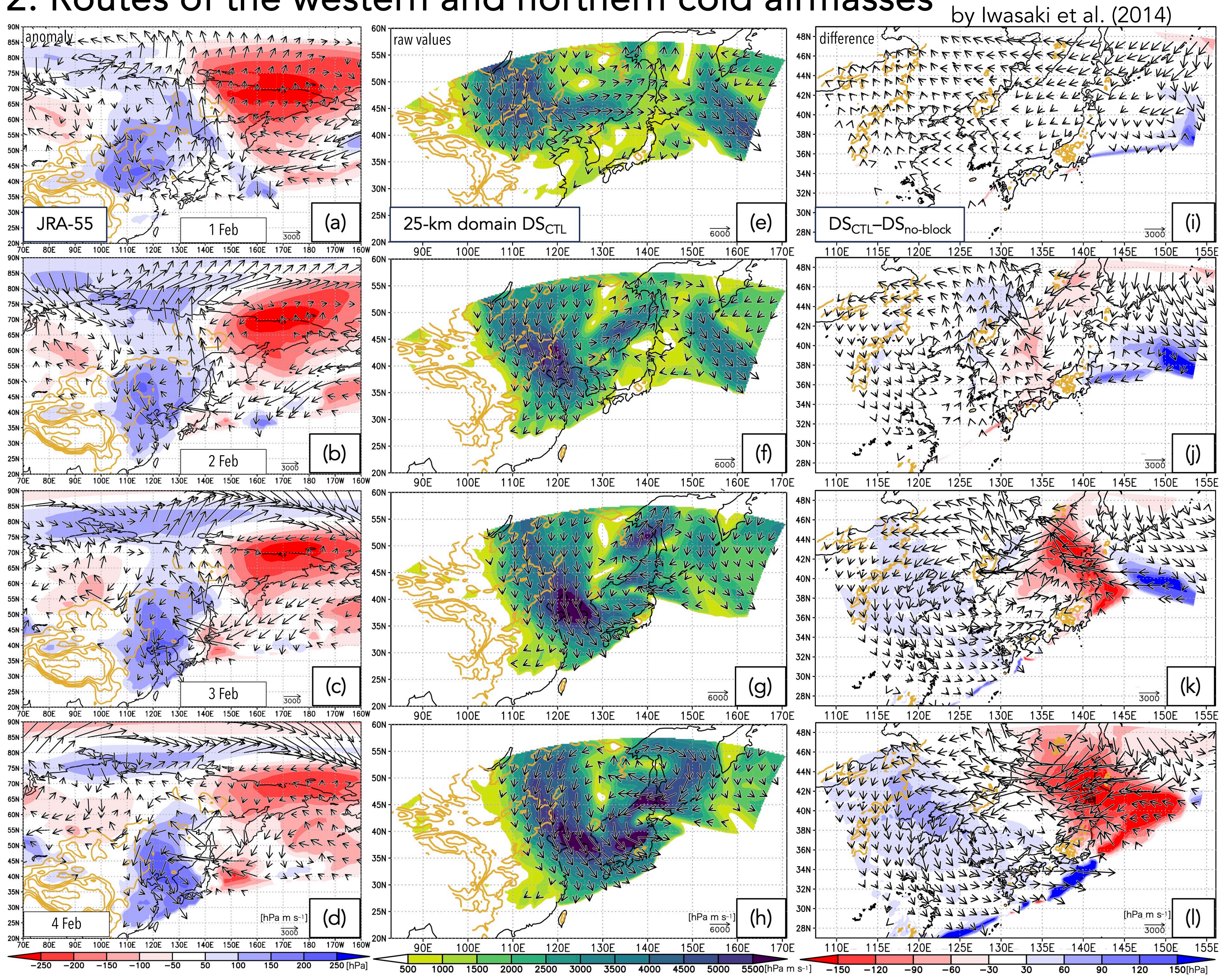

Fig. 3: Temporal sequences of (a–d) the climatological anomalies of the cold airmass [hPa] (shading) and the flux [hPa m s^{-1}] (arrows) from JRA-55, (e–h) cold airmass flux [hPa m s^{-1}] (arrows) and its magnitude (shading) in the 25-km domain DS_{CTL}, and (i–l) differences in cold airmass [hPa] (shading) and the flux [hPa m s^{-1}] (arrows) between the 5-km domain DS_{CTL} and the 5-km domain $DS_{no\text{-}block}$. Snapshot fields at 12UTC 1–4 February 2018 are shown. Brown contours indicate topography [m] with an interval of 1000 m. The threshold isentropic level of the cold airmass flux was set to 280 K.

3. Interannual relationship between East Siberian blocking frequency and the western and northern cold airmass streams

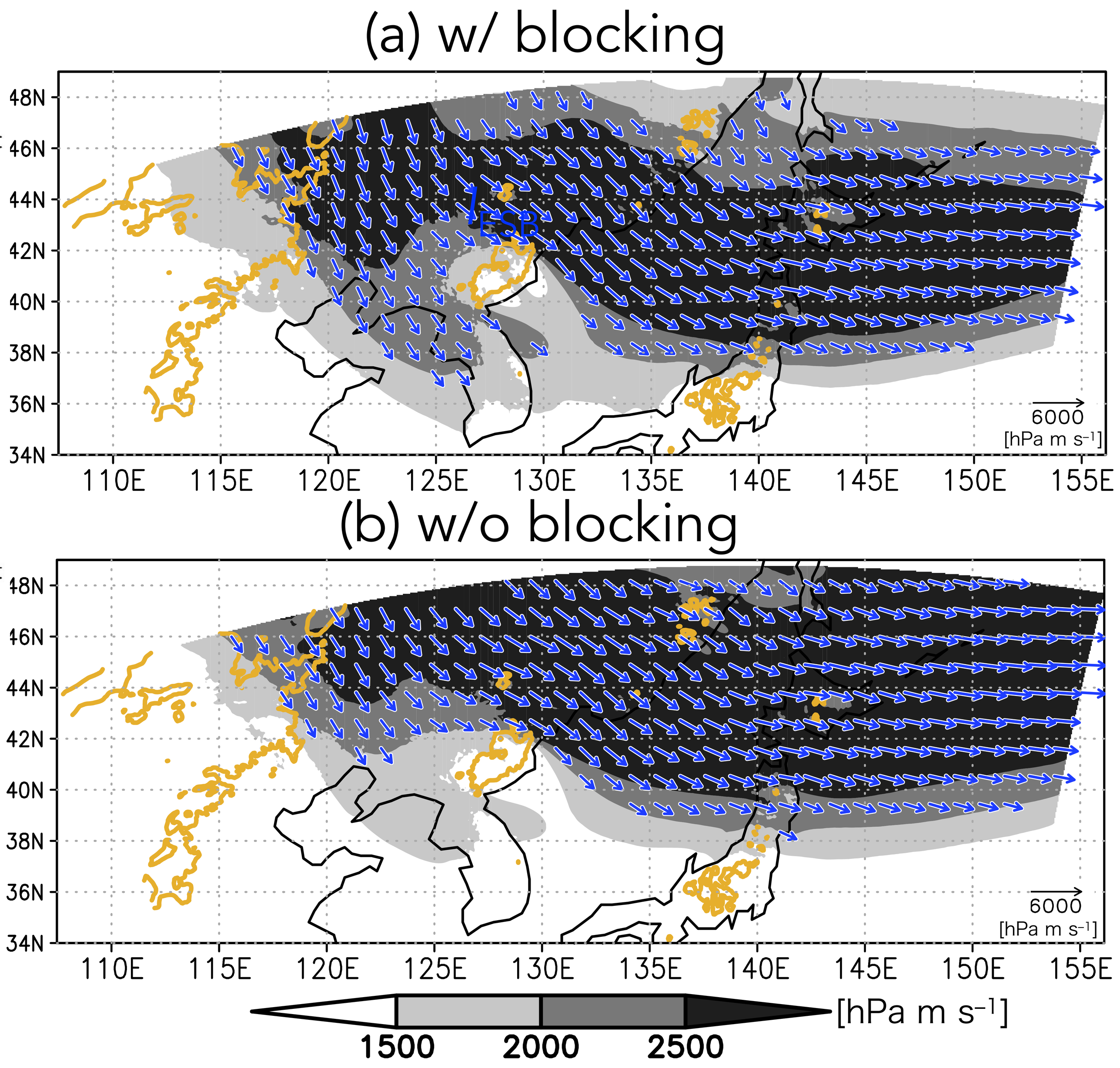

Fig. 4: Composites of the cold airmass flux [hPa m s^{-1}] (arrows) and its magnitude (shading) from the deterministic RRJ-Conv for the period December–February during 2001/02–2020/21 when East Siberian blocking (a) did occur ($I_{ESB} > 0$) and (b) did not occur ($I_{ESB} = 0$). The numbers of temporal datasets (6-h intervals) are 1830 for the blocked and 5390 for the non-blocked situations. Brown contours indicate topography [m] at an interval of 1000 m.

4. Summary

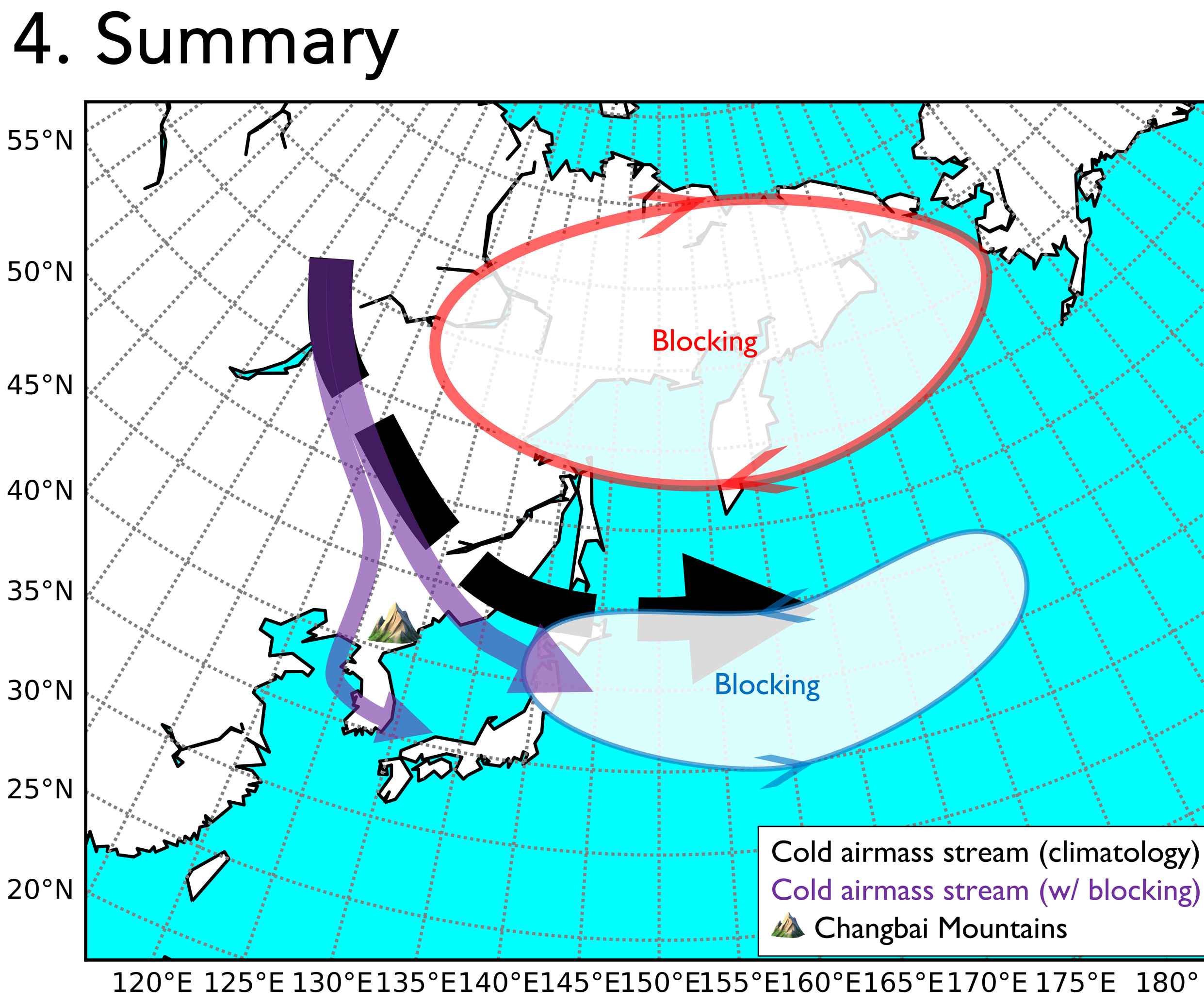

Fig. 5: Schematic showing the way in which East Siberian blocking can enhance the western and/or northern route cold airmass streams. When East Siberian blocking forms, the blocking dams (or "blocks") the climatological eastward cold airmass streams (black dashed arrow) due to the easterlies of the blocking. Because the cold airmass streams are fairly conserved around the Japan Sea, the dammed streams tend to deviate more southward and toward the Changbai Mountains (purple arrows). Thus, East Siberian blocking can enhance both the western and northern cold airmass streams toward the JPCZ region.